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The Response of Monoenergetic Gamma Rays in Finite Media Are Investigated

The transport of radiation in matter, a phenomenon useful in the field of gamma-ray spectroscopy, has been studied. The response parameters of monoenergetic gamma rays incident on various materials with finite geometries were calculated on a CDC-3600 computer. The Monte Carlo technique was used in obtaining the solution to this gamma-ray transport problem. The program permits calculations of various source geometries and detector shapes for incident gamma rays varying in energy from 5 keV to 12 MeV. The report includes results for gamma rays normal to cylindrical germanium and silicon detectors. Also presented are data representing the double and single escapes subsequent to positron annihilation occurring uniformly throughout the volume of the detector.

The theoretical energy-loss spectra and other detector–response-parameters for gamma rays are useful in the design of counter systems and in the analysis of complex spectra.

In the radiation transport process, gamma rays constitute the source. These rays enter the detector at some boundary and are diffused by the material. The radiation may be totally or partially absorbed by the medium. Primary and secondary radiations, created by the interaction collision of gamma rays with the detector material, are traced within the boundary of the detector to determine the amount of energy that escapes. This escape quantity leads to the solution of the transport problem. By generating numerous incident photons, a histogram representing the energy loss to the medium can be produced in the form of a spectrum.

The collision processes, both primary and secondary, that affect the transport of gamma rays are Rayleigh and Compton scattering, pair production, and photoelectric effect. During these processes, secondary electrons, positrons, and photons are created. The secondary photons considered are the scattered gammas in Rayleigh and Compton scattering, the fluorescent radiation subsequent to the photoelectric effect, and photons created from positron annihilation. Charged particles accounted for are Compton-scattered electrons, photoelectrons, and positrons and electrons resulting from pair production. The charged particles are slowed by two processes, namely, radiative collisions with the fields of the nuclei, and inelastic collisions with bound electrons. The radiative loses are considered to be energy imparted as bremsstrahlung photons.

The materials relevant to this investigation may be specified as single elements or organic or inorganic compounds by employing the appropriate gamma ray attenuation coefficients and various numerical constants, such as binding energies, density, etc., which are peculiar to the material under consideration. Five materials are currently used: sodium iodide, PILOT "B", cesium iodide, germanium and silicon. The first three substances are relevant to scintillation counters; germanium and silicon are elements of solid-state detectors. The type of detector is of no consequence in the theoretical calculation because the physical processes simulated are the same for all substances.

Notes:

1. The report is entitled "The Response of Monoenergetic Gamma Rays in Finite Media," ANL-7314, Argonne National Laboratory, April 1967. This report is available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151; price: $3.00 (microfiche copies, $0.65).

(continued overleaf)

2. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B69-10080

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

Source: W. J. Snow
Applied Mathematics Division
(ARG-10295)